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Interim Report No. 2

ADVANCED ASSEMBLY TECHNIQUES
FOR CAMERA TUBES

Contract AF 33(657)8675

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Approval

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Introduction

The Astroelectronics Division of Westinghouse Electric Corporation is carrying out development work on AF contract 33(657)8675 for ASD, Dayton, Ohio. The purpose of the development is to show feasibility of "Advanced Assembly Techniques for Camera Tubes". These techniques center about a concept known as "In Vacuum Processing". The photo image tube components are placed in a vacuum system, various components are processed, the tube is assembled by external manipulation, and sealed before re-exposure to atmospheric pressure.

This contract requires the assembly of several tube types; photo-diodes, an image intensifier, a photomultiplier of the Astracon type, and an image Orthicon. The characteristics of these tubes will be carefully evaluated and compared to similar commercially available types.

The work of the first interim period was primarily the establishment of processes necessary for the assembly of the various tubes, and the definition of conditions under which the processes may be carried out. This general aim has been further pursued in the second quarter and some actual assembly and tube evaluation has been made.

More specifically the aims of this report period were:

1. Photocathode Processing

Work out techniques for processing S-1, S-10 and S-20 surfaces. Correlate gas partial pressures and cathode stability.

2. Seal Techniques

Improve the indium-glass bond. Investigate metallizing and other treatments of the glass surface.

3. Remote Handling Techniques

Evaluate the external manipulator using sapphire ball bearings.

Evaluate performance of the bakeable metal system.

4. Experimental Tubes

Procure parts for two inch diameter photomultiplier tubes.

5. Evaluate Experimental Tubes

Life test experimental diodes.

Photocathode Processing

One of the main problem areas of this work has been the transfer of the photocathode from the formation station to the press or assembly position without loss of sensitivity. The ambient atmosphere in the photo formation station is different from the environment seen by the photocathode in the main vacuum section for two main reasons. One, the photoevaporation chamber is separately pumped and its seal is sufficiently tight to establish a pressure differential between the two chambers. Two, the evaporation of alkali metals during photoformation coat the entire chamber and act as gettering materials for ambient gases as well as for those liberated just prior and during the alkali generation process.

It has been our experience that a processed photosurface can be stored in the evaporation chamber for as long as 24 hours without loss of sensitivity. However, if the photocathode is exposed to the external vacuum, replaced, and the sensitivity rechecked, we find an exponential decay of sensitivity with time and a linear dependance of the decay constant with pressure. The decay constant also decreases with temperature.

The meaning of this experiment, we interpret in the following manner. Inside the photoevaporation chamber the number of detrimental molecules being adsorbed on the photosurface is very

small as a function of time, and on exposure the number is proportional to the number present in the main chamber. The adsorption coefficient is inversely proportional to the temperature of the photocathode. Since the transfer of photocathodes must be made without loss, a solution of the problem must be found.

The solution can be found either by removing the detrimental molecules from the transfer system or by removing the surface layer from the cathode in the finished tube. We have built and placed in operation (at the end of this quarterly period) a bakeable, all metal, vacuum system. This system is capable of all assembly operations necessary to fulfill the requirements of this contract. The initial operation of the system showed a pressure capability of 2×10^{-8} mm Hg after a six hour bake. The seasoned system will give us an operating pressure of 1×10^{-9} mm Hg. The transfer can be made at this pressure without significant loss if our data can be extrapolated. The adsorbed layer can be removed from the surface of the sealed tube if the sealed tube has any facility for pumping. This can be accomplished with an appendage pump or a gettering surface with greater adsorption power than the photosurface itself.

We know from experiment that the photosurface does not permanently change character until a measurement of sensitivity is made. If the sensitivity is measured at very low light level after exposure, the initial readings are higher than the steady state values at high light levels. The light and potential at the surface are necessary for permanent damage. On the basis of this observation a careful voltage seasoning cycle was carried out on a vacuum assembled image intensifier prior to light exposure. The sensitivity of the cathode was only 20μ amps per lumen, however, the sensitivity did not change within the limit of 25% error. It did not change as much as would be expected without the seasoning cycle. We will not speculate at this point as to what happened until we have further evidence.

During this report period we have made numerous S-20 photocathodes in an 18 inch glass bell jar system. Six in October, two in November, five in December, five in January. The best surfaces were made in October. At least one surface made at that time had a peak response greater than 100μ amps per lumen.* Since then, photosurfaces made in that system have had poorer and poorer response. In January the average response of the S-20 surfaces was 20μ amps per lumen. We know from this that there must be a contaminant present in the system. However, since we know that all final efforts will be made in the all metal system, little effort has been made to trace the source of contamination.

Processes were established for making S-1 surfaces. The main problem here was to make an easily controllable oxygen source.

We found that a channel filled with MnO_2 , plus heat in the photo-evaporation chamber, gave a usable, well controllable, oxygen yielding reaction. The MnO_2 decays to $2MnO + O_2$ at about $550^\circ C$. Not only were we able to sustain pressures of 50μ over a considerable period of time, but we were able to well control the base pressure of the vacuum system from 1×10^{-8} mm Hg to the high pressures. The MnO_2 plus heat reaction has considerable advantage over the analogous Ag_2O one. The Silver Oxyde reaction takes place at $350^\circ C$. This means that the source must be removed from the faceplate in the photoformation chamber because it would seriously limit the bake temperature. Removal of the source from the chamber might cause time delays which could cause process control failure. We have also obtained a silver tube oxygen source which would be capable of giving us ultra

*Since we do not have a color temperature calibrated light source in this system we cannot give an exact response quote.

pure oxygen should this be necessary. Work on S-10 surface processing has been delayed to be done in the bakeable system.

Seal Techniques:

Tools have been designed, and procedures developed to vacuum cast indium rings of 2 and 3 inch size, by means of induction heating. The molten indium is outgassed, and the visible oxide layer removed during the casting procedure.

At dull red heat (approx. 700°C) the melt is supported by a frosted quartz mold. The solidified indium does not stick to the frosted surface after cool-down, if this surface is kept clean. The entire casting procedure, including pre-casting and cleaning of the rough ring, takes approx. 30 minutes, about 60% of which is cool-down time. The established procedures for handling and storing the finished rings, in conjunction with purchasing of the most suitable ingot indium of 99.999 + % purity yield a product with considerably improved vacuum sealing properties.

These rings used in conjunction with image intensifier type tubes have given reliable seals. These tubes are sealed at $1 - 5 \times 10^{-8}$ mm Hg and have shown a shelf life of up to one month without developing an Ion spot. This image intensifier will show an Ion spot at 1×10^{-7} mm Hg.

Handling Techniques:

Great care has been taken to design manipulation facility in the all bakeable vacuum system. The manipulation system must operate in high vacuum after a period of bake. It is believed that sapphire ball bearings will not weld or bind under the expected conditions of operation.

A trial manipulator with sapphire ball bearings was made for the 18 inch glass bell jar system. This manipulator has performed satisfactorily for several months. It was given a bake to approx. 150°C and at least under these conditions no evidence of binding or sticking was found. A new mechanism for manipulator locking was designed and constructed during this report period. The locking mechanism rotates on a sapphire ball bearing and the closing lever arm is longer than on earlier models. The trial manipulator showed us that the increase in lever arm was necessary for finer control in parts handling.

Other manipulation tooling designed and constructed for this program include:

- a) Bellows manipulators
- b) Turntable for parts positioning
- c) Sealing press
- d) Photoevaporation chamber
- e) Electronic equipment, photomultiplier, power supplies, and associated tooling.

Experimental Tubes:

Image intensifiers, astracon and photodiode type tubes were made during this quarter. The tooling fixtures as well as parts for these tubes have been made or placed on order.

An intensive program is underway to improve the reliability and operating characteristics of the secondary emission transmission multiplier films. These films, if not carefully processed, will fail during pump-down and tube life.

Primary effort has been placed on substrate treatment. The substrate consists of an alumina film. The film is made from the metal by an anodizing and etching process. We have found that

this film is much more stable after air or vacuum baking at 400°C. It has also been found that the dynodes are much more stable if, during the KCl evaporation the alumina ring holder metal junction is shielded. Apparently recyrstalization of the KCl causes breakage in this area.

The combination of these processing steps with our existing schedule has allowed the successful assembly of several thin film tubes.

Cold press indium seals were made on reject image orthicons. The rejects were cracked open by applying a flame to a scribe mark on the bulb. This procedure gave us a clean surface, which we subsequently resealed with cold pressed indium. Two seals of three starts were leak tight. On the third the faceplate was lost before seal could be made.

The success of this procedure is very important. It means that we can use conventional image orthicons for our work, which means a great saving in cost. Also the design criterion for fixtures in the all metal vacuum system were established.

Evaluation of Experimental Tubes:

It was originally planned that the photomultiplier tube would be two inches in diameter. However, it was decided during the last quarter to make an inch and five eighths tube. This diameter conforms with our previous work on photodiodes and makes tooling simpler.

Life tests on photodiodes have shown 3 tubes with the indium seal to be stable for 1000 hours after an initial slump of approx. 50%. These were S-11 surfaces and the initial slump

is accounted for by transfer damage.

One four-stage photomultiplier tube was made. Little evaluation was possible before breakage of films from ionized gas. Two single stage photomultipliers were successfully assembled. These were made to evaluate the effects of process changes. The two tubes successfully withstood high voltage on the dynodes and were apparently relatively gas free. However, due to an error in the electron optics transmission of electrons through the films could be seen only in the center portion of the cathode. In this case the electrical characteristics are not as important as the successful mechanical assembly capable of any operation.